Elliott Bay Nearshore Substrate Enhancement Project Monitoring Report: evaluation of the utilization of substrate diversity and the production of prey taxa important to juvenile salmonids in 1998 and 1999

Prepared for the
Elliott Bay/Duwamish Restoration Program Panel

by

Kimberle Stark, King County Department of Natural Resources,
Jeff Cordell, University of Washington, and
Margaret Duncan, The Suquamish Tribe

Panel Publication 26
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The Panel of Managers holds regularly scheduled meetings that are open to the public. Technical Working Group and committee meetings are scheduled on an as-needed basis, and are also open to the public. Meetings are generally held at the National Oceanic and Atmospheric Administration, National Marine Fisheries Service-Regional Directorate Conference Room, Building #1, 7600 Sand Point Way, NE, Seattle. The Panel recommends that you contact the Administrative Director at the above phone number to confirm meeting schedules and locations. The Panel also holds periodic special evening and weekend public information meetings and workshops.

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1. Introduction

Project Description

The Elliott Bay Nearshore Substrate Enhancement Project was undertaken by the Elliott Bay/Duwamish Restoration Program Panel (Panel) in March 1998 at selected sites northeast of Duwamish Head on Washington Department of Natural Resources (WDNR) property and seaward of Seattle tidelands north of Seacrest Park in West Seattle. The King County Department of Natural Resources (King Co, DNR) was selected as project manager subsequent to site investigations by the Washington Department of Fish and Wildlife (WDFW) in 1996. The Panel's Habitat Development Technical Working Group provided guidance during the project design phase and in the development of the monitoring plan.[1]

Four materials (cobble, quarry spall, pea gravel and oyster shell) were placed in eight plots (four plots each at two sites) to enhance productivity of benthic infauna, increase the distribution and density of macroalgae and other primary producers, and improve the attributes that support resident and migratory marine and estuarine fish species (Figure 1).

Specific objectives were identified as follows:

- Increase diversity of bottom substrates
- Increase area of limiting hard bottom substrates
- Provide intertidal substrates for bait fish spawning
- Provide suitable substrates at proper horizons for eelgrass
- Increase volume of physical and protective structures for juvenile and adult resident invertebrates and fishes
- Increase hard structure surfaces for macroalgae
- Remove undesirable bottom debris

[1] Elliott Bay Nearshore Substrate Enhancement Monitoring Plan. May 2000. Elliott Bay/Duwamish Restoration Program Panel Publication No.25

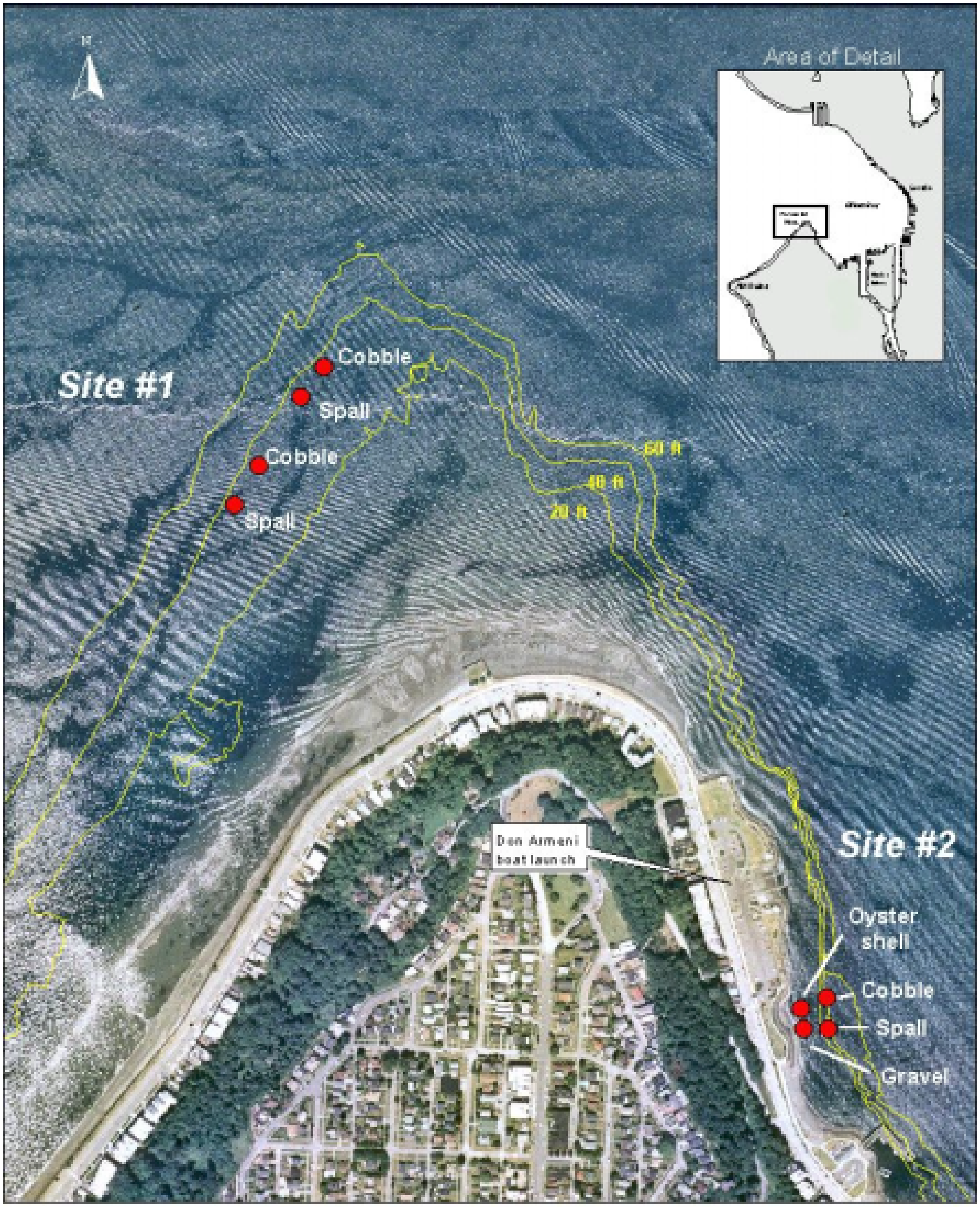

Figure 1. Elliott Bay Nearshore Substrate Enhancement Project Location

Condition Prior to Substrate Enhancement Project

Duwamish Head (Site #1)

Pursuant to field investigations conducted by WDFW under contract to the Panel, the substrate was described as sand, mixed fine (Buckley, undated). In addition to patches of eelgrass, the presence of large macrophytes at relatively deep depths at Duwamish Head was recorded. A checklist of species found at the site is provided in Appendix A. WDFW divers determined that

> “The apparent stability of the substrate in the area (based on probe penetration depths and habitat specificity of the species of infauna) indicates limited, if any, need for engineering analyses for construction; patches of high biodiversity created by the limited rock substrates and the currents caused by tidal exchanges all indicate a high potential for a significant increase in the biodiversity and densities of species in the Elliott Bay area resulting from benthic habitat enhancement [at] Duwamish Head.”
> (Buckley, April – May 1996 Progress Report).

Seacrest Park (Site #2)

Based on field investigations, WDFW advised the Panel that the subtidal area in the vicinity of Seacrest Marina reflected a favorable physical profile and potential for high biodiversity. Bottom contours indicated a variably sloping substrate with some shelf areas. Substrate was described as sand, mixed fine, mixed coarse, gravel, silty gravel, gravel-sand-silt mixture; gravel sand mixtures, organic silts and organic silty clays of low plasticity; clayey sand, sandy-clay mixtures; well-graded sands and gravelly sands, little or no fines. A checklist of species identified in the area is provided in Appendix A. (Buckley and Bookheim, December – March 1996 Progress Report)

Project Design and Implementation

The substrate materials used were chosen based upon their likelihood of achieving project goals. The larger materials, cobble and quarry spall, were chosen to increase the substrate and surface area for macroalgae attachment as well as provide cover for fish and invertebrates. The oyster shell was chosen to provide habitat for juvenile Dungeness crab specifically. The pea gravel was selected to provide habitat for juvenile salmonid prey.

Approximately 40 cubic yards of materials were placed by barge and crane in eight plots in March 1998. A description of the plot configuration at each site is provided below (see Figure 1 for location).

<u>Duwamish Head (Site #1)</u>

Two plots of cobble and two plots of quarry spall were placed near the –35 feet (ft) mean lower low water (MLLW) bathymetric contour at this site. Each plot was composed of approximately five cubic yards and measured approximately 10 ft x 10 ft. All plots were less than 18 inches (in.) high.

<u>Seacrest area (Site #2)</u>

Approximately one five cubic yard plot of pea gravel and one five cubic yard plot of oyster shell were placed at depths from –2 ft to –12 ft MLLW. The oyster shell plot measured approximately 10 ft by 20 ft, with a shell layer depth of about 6 inches. The pea gravel plot also measured approximately 10 ft by 20 ft.

One plot of quarry spall and one plot of cobble, each about five cubic yards and approximately 10 ft by 10 ft, were placed near the -35 ft MLLW bathymetric contour. Each plot contained rocks ranging in size from 2 to 12 in., with an average 12 in. thickness and height less than 18 in.

2. Monitoring Schedule, Tasks, and Methods

The Elliott Bay Nearshore Substrate Enhancement Monitoring Plan (May 2000) provides detailed descriptions of the project area and the monitoring tasks and methods. The monitoring of treatment and control areas provides for the post construction assessment of physical stability, productivity of benthic infauna, distribution and density of macroalgae and other primary producers, and improvement in attributes that support resident and migratory marine and estuarine fish species.

Monitoring Schedule

Table 1 displays the monitoring dates for Sites #1 and #2 for years 1 and 2.

Physical observations of quarry spall, cobble, pea gravel and shell plots occur in years 1, 2, 3, 4, and 5.

For years 3 to 5, observations are to occur semi-annually in February or March and July or August, and more often as resources permit (Table 2).

Epibenthic invertebrate sampling of the gravel plot occurred in April 1998, May 1999, and April 2000. This report provides monitoring results for years 1 and 2 (1998 and 1999). Additional epibenthic invertebrate sampling is scheduled to occur in years 4 and 5 in both April and May if resources permit. Monitoring for the settlement of juvenile Dungeness crab in the oyster shell plot occurred in July and August 1998; no further sampling is scheduled.

Table 1. Project Monitoring Schedule: 1998 and 1999

	Date	Type of Monitoring	Substrate
Duwamish Head (site #1)	27-Feb-98	Video	all
	25-Mar-98	Video	2 piles closest to shore
	19-Jun-98	Video	all
	28-Jul-98	Video	all
	27-Mar-99	Video	all
	27-Aug-99	Video	all
Seacrest (site #2)	28-Feb-98	Video	all
	25-Mar-98	Video	all
	30-Apr-98	Epibenthic invertebrate sampling	gravel, sand (control)
	13-Jul-98	Video	all
	23-Jul-98	juv. Dungeness crab survey	oyster shell
	18-Aug-98	juv. Dungeness crab survey	oyster shell
	27-Mar-99	Video	all
	24-May-99	Epibenthic invertebrate sampling	gravel, sand (control)

Table 2. Five Year Monitoring Schedule: 1998-2002

	Type of Monitoring	Year Monitored	Frequency	Month (s)	Substrate
Duwamish Head (site #1)	**Physical**	Year 1 (1998)	Quarterly	February, March, June, July	all four plots
		Year 2-5 (1999-2002)	Semi-annual	February or March July or August	all four plots
Seacrest (site #2)	**Physical**	Year 1 (1998)	Quarterly	February, March, July *	all four plots
		Year 2-5 (1999-2002)	Semi-annual	February or March July or August	all four plots
	Biological juv. Dungeness crab survey	Year 1 (1998)	Annual	July	oyster shell
	salmonid prey survey	Years 1-2 (1998,1999) Years 3-5 (2000-2002)	Annual Semi-annual	April or May April, June	pea gravel pea gravel

* plots were not monitored in August

Tasks and Methods

Three post-construction monitoring tasks were used at site #2: physical observation, epibenthic invertebrate sampling, and juvenile Dungeness crab assessment. Physical observation was the only monitoring method employed at site #1.

Physical Observation: Physical observations of all plots at both sites were made by scuba divers and filmed using an underwater video camera (8-mm video tape). All plots were designated with ropes and/or floats to assist divers in locating the plots. Divers filmed the center of the plots as well as the perimeter. Observations were intended to assist in the assessment of sediment accumulation, fish presence, macroalgae presence, and the areal extent and configuration of substrate treatments.

Epibenthic invertebrate Sampling: Monitoring for production of invertebrate prey taxa known to be important to juvenile salmonids was conducted at Seacrest (site #2) for the pea gravel plot on April 30, 1998 and May 24, 1999. For each sampling event, five samples were collected from the pea gravel plot at an average tidal height of -22 MLLW. In addition, five samples were collected from an untreated area adjacent to the pea gravel plot which served as a control plot. However, due to resource constraints, only three samples collected from each plot were analyzed.

Samples were collected with a gas powered centrifugal water pump, sucked through a 15 meter long (51 mm inner diameter) hose, connected to a cylinder 0.35 meter wide and 0.38 meter high (Figure 2). The sampling cylinder had ports covered with a 130 micron mesh net to minimize collection of extraneous material and allow water flow. The water in the cylinder was evacuated and all water entering the cylinder passed through the screened ports. The epibenthos was captured in the mesh net and then screened using a 253 microns sieve with rinse water. All rinse water was filtered to avoid sampling contamination. The organisms remaining on the sieve were then transferred to a sample container and preserved in a 10% buffered formalin solution (samples were later transferred to a 70% alcohol solution). To ensure siting of the pump head, an underwater video camera was mounted so that a "live" image of the substrate could be monitored as samples were taken. A hand winch was used to lower the head slowly with minimal disturbance to the substrate. The boat was anchored and moored from the bow and stern to ensure that the head remained stable on the sample substrate. The pump was operated long enough to move at least three times the volume of the entire system, approximately 30 seconds. The centrifugal pump system was developed at the University Of Washington School of Aquatic and Fishery Sciences (Simenstad et al. 1991).

<u>Juvenile Dungeness Crab Assessment</u>: Monitoring for juvenile Dungeness crab settlement was conducted at site #2 for the oyster shell plot only. For each sampling event, 10 samples were collected using a hand-held Venturi suction dredge within a 14 m^2 metal frame. Samples were sorted, identified, measured, and returned live. Ten samples were also collected from an eelgrass bed (northwest of the oyster shell plot) which served as a control site (see Dinnel and Hora for a detailed description of monitoring methods and results.

Figure 2. Epibenthic pump system

3. Monitoring Results

<u>Site #1 – Duwamish head</u>

Cobble and spall plots

The Duwamish Head project area (site #1) was monitored with 8-mm video in February 1998 prior to substrate placement in March 1998. The pre-construction video showed the native substrate at site #1 was composed mostly of sand, with numerous orange sea pens in the area.

The first post-construction observations were made approximately two weeks following substrate placement (see Table 1 for monitoring dates). This video showed that benthic diatoms were covering the quarry spall and cobble at the two substrate plots placed closest to shore, particularly the spall plot which is the farthest south. The two northern plots were not videotaped because they could not be located by the divers conducting the monitoring.

A video survey was conducted in June; however, poor visibility made cataloging algae and organisms difficult.

The July 1999 monitoring observations detected several macroalgae species attached to the substrates on all four plots. Several invertebrates, such as anemones, barnacles, sea stars, and shrimp were seen on or around the rocks. Heavy barnacle growth was noted at all plots. Fish, such as sculpins, sole, greenling, and juvenile rockfish were present as well. It appeared that wherever hard substrate was available, macroalgae and sessile invertebrates had attached.

The site was monitored again in August 1999 and showed significant microalgae growth at all the plots. Although a species and estimated abundance list has not been produced, there was more macroalgae growth noted during this survey than previous videos. Monitoring in March 1999 showed similar macroalgae and invertebrate species present in 1998. It was difficult to see the actual substrate plots due to the heavy macroalgae growth. Macroalgae had also attached to the ropes that were placed to guide the divers to the substrate piles.

Site #2 – Seacrest Area

Quarry Spall and Cobble Plots

The quarry spall and cobble plots at site #2 were monitored in February 1998, two weeks following substrate placement. Although the cobble and spall plots were bare, the oyster shell was heavily covered with benthic diatoms. Diatom growth was detected in the gravel plot; however, it was not as easily distinguishable as on the oyster shell. Scheduling conflicts precluded the plots being monitored in June.

The July monitoring observations documented that macroalgae species had attached to the cobble and spall plots. Barnacles had settled on the larger rocks and many types of invertebrates were seen on or in between all the substrates. Several small fish, including perch and juvenile rockfish, were seen around the oyster shell plot, along with macroalgae. The macroalgae on the oyster shell was composed mainly of the green alga, *Ulva spp*. The gravel showed diatom growth but other organisms were hard to distinguish. Although not reflected in the video, divers conducting the monitoring reported seeing several shrimp among the substrates.

The March 1999 monitoring showed similar macroalgae and invertebrate species present as observed in post-construction monitoring in 1998. The gravel plot appeared to have eroded slightly and had dispersed down the slope ASK RANDY.

Site #2 Pea Gravel Treatment Biological Success

Detailed lists of 1998 and 1999 epibenthic fauna results are provided in Appendices B and C, respectively. Monitoring for both 1998 and 1999 reflected the presence of important prey fauna for many juvenile stages of Puget Sound fish. Table 3 shows juvenile fish prey present in the gravel and control plots in 1998 and 1999.

Table 3. Juvenile Fish Prey Results for 1998 and 1999(mean densities No./m^2)

	Pea gravel plot		Control plot	
	1998	**1999**	**1998**	**1999**
Juvenile Salmonid Prey				
Harpacticus copepodids	13.3	0	0	0
Harpacticus compressus	13.3	0	0	0
Zaus spp.	53.3	0	16.7	6.7
Tisbe spp.	1560	8070	2510	3303.3
Dactylopusia vulgaris	2346.7	12000	9173.3	843.3
Dactylopusia crassipes	0	0	33.3	0
Cumella vulgaris	26.7	3.3	80	6.7
Chironomidae larvae	0	0	3.3	0
Total:	4,013	20,073	11,817	4,160
Other Juvenile Fish Prey				
Longipedia sp.	0	0	13.3	0
Ectinosomatidae	586.7	66.7	1090	86.7
Harpacticus obscurus grp.	213.3	66.7	273.3	90
Amphiascopis cinctus	80	73.3	63.3	13.3
Amphiascoides sp.	26.7	0	0	0
Aoroides sp.	30	130	180	6.7
Pontogeneia cf. Rostrata	110	63.3	153.3	10
Ischyrocerus sp.	26.7	140	13.3	16.7
Caprellidae	0	3.3	20	3.3
Total:	1,073	543	1,807	227

Harpacticoid copepods, *Harpacticus uniremis* and *Tisbe* spp., were found in both the gravel and control plots in 1998 and 1999. *Harpacticus* spp. were found at similar densities for both the gravel and control plots in 1998 and also in 1999. Other harpacticoid copepods, *Zaus* spp. and *Dactylopusia* spp., were also found at both plots. *Zaus* spp. were found in low densities for both plots in 1998 and in the control plot in 1999, but were not found in the gravel plot for 1999. Two cumaceans, *Cumella vulgaris* and *Lamprops quadriplicata,* were found in low densities (less than a mean of 28/m^2) at both plots in 1998 and 1999. However, *Lamprops quadriplicata* was only seen in the gravel plot in 1999 at a low mean density of 3.3 /m^2.

Figure 3 displays densities of harpacticoid copepods, gammarid amphipods, and total epibenthos for samples collected in 1998 and 1999. Results show higher overall abundance for the gravel plot in 1999 than in 1998 and an increase in total harpacticoid abundance in 1999. This is due primarily to higher numbers of two harpacticoid copepod species found in the gravel plot in 1999: *Dactylopusia vulgaris* and *Tisbe* spp. *Dactylopusia vulgaris* had a mean density (No./m^2) of 2,347 in 1998 compared to 12,000 in 1999. Likewise, *Tisbe* spp. had a mean density (No./m^2) of 1,560 in 1998 compared to 8,070 in 1999.

The control plot shows the opposite of the gravel with a decrease in overall abundance and total harpacticoid abundance for 1999. This decrease is largely due to fewer numbers of *Dactylopusia vulgaris* found in 1999. For *Dactylopusia vulgaris,* a mean density (No./m^2) of 9,173 was found in 1998 compared to 843 in 1999.

Figure 4 presents densities of salmon prey taxa, other fish prey taxa, and non-prey taxa for the samples collected in 1998 and 1999. In general, results reflect higher density increases for salmonid prey harpacticoid copepods in the gravel plot in 1999 than were observed in 1998, one month after project implementation. As stated above, this is due to increases in *Dactylopusia vulgaris* and *Tisbe* spp., which are both known to be juvenile salmonid prey.

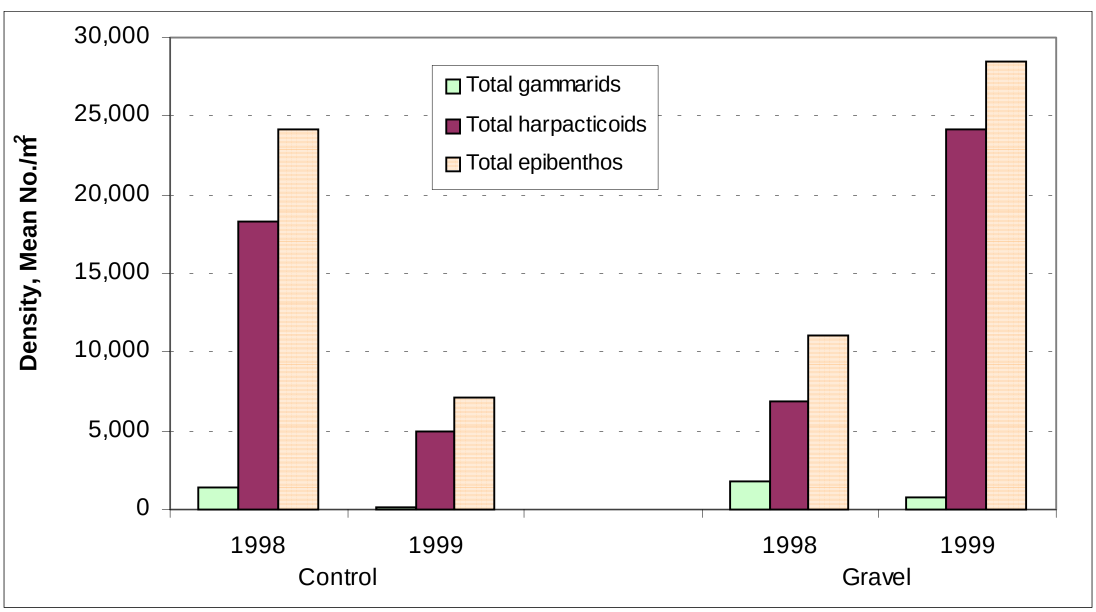

Figure 3. Abundance of gammarid amphipods and harpacticoid copepods for the gravel and control plots at site #2 (Seacrest): 1998 and 1999.

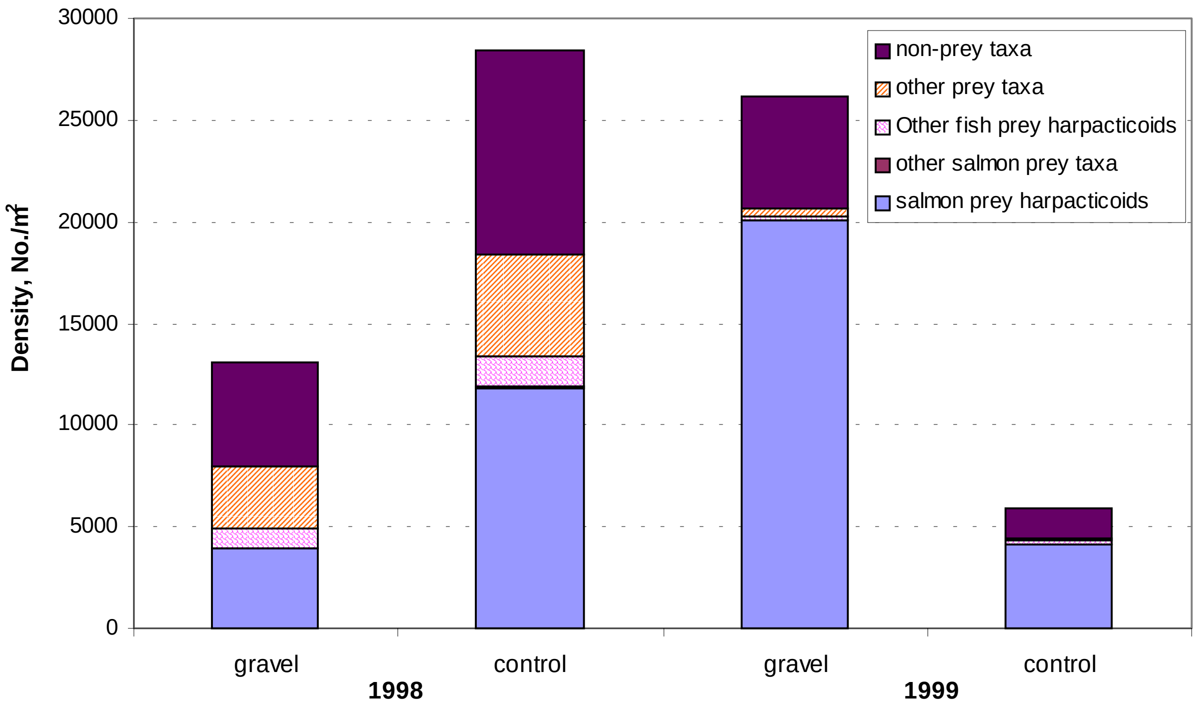

Figure 4. Abundance of salmonid and other fish Prey at site #2 (Seacrest): 1998 and 1999.

Site #2 – Oyster Shell Plot Biological Success

The oyster shell plot at Site #2 and the "control" eelgrass area near Duwamish Head were sampled twice during July and August 1998 for the presence of juvenile Dungeness crab, *Cancer magister*. Although no settlement of juvenile Dungeness crab was detected in the oyster shell plot, other crab species, fish and invertebrate fauna were present. Low densities of juvenile Dungeness crab were found in the control eelgrass bed. Monitoring methods and results are provided in a report produced by the Panel in November 1998 (Dinnel and Hora, 1998).

4. Discussion

Although detailed species list and estimated algae and/or invertebrate abundance have yet to be produced, the video monitoring shows the materials placed at both sites were effective for providing macroalgae and sessile invertebrate attachment sites. The macroalgae is providing cover for several fish species, including sole and rockfish. The macroalgae, and the substrates themselves, are also providing cover for many invertebrates, such as crabs and shrimp.

The effectiveness of the pea gravel application cannot be determined conclusively due to the limited number of samples and inherent high variability between samples and years for epibenthic fauna. Thus, it is not possible to detect statistically significant differences between the gravel and control epibenthic assemblages. However, general observations suggest that the overall abundance of epibenthic invertebrates, including juvenile salmonid prey taxa, increased in 1999 when compared to the 1998 results.

Harpacticoid copepods, *Harpacticus uniremis* and *Tisbe spp*., are especially prominent in the diet of juvenile salmonids (Simenstad et al. 1979, 1988). *Tisbe* spp. was found in both the gravel and control plots in 1998 and 1999. Juvenile chum and pink salmon, Pacific herring, surf smelt, Pacific sand lance, and three spine stickleback have been found to feed heavily on *Tisbe spp*., *Zaus spp*, *Harpacticus spp.*, and *Dactylopusia spp*. (Simenstad et al 1979, 1988, 1991; Sibert 1979; Healey 1979; Landingham 1983, from Groot and Margolis 1991). Representatives from each genus identified above were found in both plots. Cumaceans (*Cumella vulgaris* and *Lamprops quadriplicata*) are prey of juvenile chinook and coho salmon (Simenstad et al. 1988). *Cumella vulgaris* was found in low densities at both plots in 1998 and 1999, but *Lamprops quadriplicata* was only seen in the gravel plot in 1999 at a low density.

Impacts of substrate modification are often complicated by different responses of the taxa at different times and sites. Simenstad et al (1991) reported varying impacts in their study of gravel application to intertidal mud and sand substrates in two embayments in Hood Canal and south Puget Sound: Bywater Bay and Oakland Bay. Cumaceans and several other taxa were depressed relative to untreated sites on sandflats of Bywater Bay, while *Tisbe spp*. and

Zaus sp. were strongly enhanced. Their mudflat site at Oakland Bay showed contrasting results, with enhanced numbers across most taxa. Whether or not the epibenthic assemblages at this project site follow either of these two patterns is not yet known.

The oyster shell plot at site #2 does not appear to be effective for providing habitat for juvenile Dungeness crab. Although the shell plot was only sampled during the first year, no Dungeness crab were found and only a small number were found in the control plot. Factors limiting larvae settlement may have included overall low abundance of Dungeness larvae in Elliot Bay in 1998 and the depth of the oyster shell plot. Although the oyster shell plot did not attract Dungeness crab, the plot did provide complex habitat for other crab species, invertebrates, and small fish (Dinnel and Hora).

6. Recommendations

Video surveys of all plots should continue.

Sampling activities in years 3 to 5 should be conducted in the same month as occurred in the year 1999 (May).

Vertical migration of the oyster shell and gravel plot needs to be assessed. It is possible that this could be accomplished by placing markers at the end of the current plots and measuring migration for subsequent surveys.

A detailed species list, including estimated abundance, needs to be produced for every video survey. The data should be entered into a database, possibly an Excel spreadsheet, for analysis.

To aid in the assessment of species diversity and abundance, densities in cobble and spall plots at Sites #1 and #2 should be estimated in addition to listing macroalgae and macro-invertebrates, fish numbers and species.

For more conclusive investigation on the functional use of the substrate modification by fish and epibenthic crustaceans, the project might use fish and gut surveys in addition to further meiofauna collections taken with greater frequency in the late winter and spring. Cordell (1986) found species specific distribution curves through his study season, with *Harpacticus uniremis* having a single discrete peak of abundance, while *Tisbe spp*. had multiple peaks over an extended Spring period.

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